Urban Transport and the Environment
An International Perspective
Urban Transport and the Environment
An International Perspective

World Conference on Transport Research Society
And
Institute for Transport Policy Studies

United Kingdom – North America – Japan
India – Malaysia – China
At the present time, emissions of greenhouse gases from transport are continuing to rise in almost all countries, at a rate much higher than those from industrial or domestic use. If this trend continues, transport will certainly be the largest sector influencing the global atmospheric environment in the 21st century.

Even now in many of the developed countries, car ownership and use are continuing to rise. On the other hand, although engine technology has recently been much improved, the usage level of low emission cars is still much lower than that needed to clear up environmental problems. For this reason, the reduction of local atmospheric pollution caused by transport in urban areas has also not been as successful as it should have been.

In developing countries, along with the increase in income, there is a rapid shift from walking and cycling to motorised transport. Since many of the motorized vehicles are aged or poorly maintained, deterioration of the environment especially in urban areas has been getting worse. Especially in rapidly growing countries, where motorisation is occurring at a very swift pace while the automobile maintenance system is not developing at the corresponding rate, local environmental pollution is very serious. Moreover, the potential impact of this local traffic on the global environment as a whole is becoming critical.

Although various countermeasures have been taken both in developed and developing countries, their effects have tended to be limited because of lack of systematic implementation. It is also a sad fact that the valuable experiences of one country are not sufficiently reflected in the policy measures taken by other countries. In order to adequately address the environmental problems arising from transport, it is imperative to gather the policy experiences from each country into a knowledge-base which can be shared by all.

This book focuses particularly on urban transport, since this is a serious local issue with a significant influence on the global environment. It attempts firstly to understand the current conditions of urban transport and the environment. Then it tries to give a picture of what sort of measures can be taken to improve the situation and what their effects on the environment would be. For this purpose, the relationships of the various objectives, measures and effects are first presented systematically. Since these objectives, measures and effects may differ from country to country and from city to city, experiences in different cities in the world, collected through international cooperative research, are presented. By compiling them into a future perspective for transport and the environment, the book aims to identify future issues and suggest policy directions to contribute to more integrated measures for cities around the world in order to improve the local and global environment.

For understanding the environmental problems of urban transport and finding suitable countermeasures, it is important to have adequate knowledge not only of transport planning and engineering but also of the mechanisms of environmental impacts and of the effectiveness of measures. This book is designed for researchers, practitioners and students who work in either the transport or the environment field and are interested in an integrated understanding
of both. In addition, we hope that for those attempting to take a cross-speciality approach to the
development of policy measures, it will serve as a reference to promote further international
collaborative research and cooperative work.

A Special Interest Group on Transport and the Environment was established at the 9th
Seoul Conference of the World Conference on Transport Research Society (WCTRS) held in
July 2001, together with another related Special Interest Group on Transport Policy
Instruments. A major trigger for this initiative was the growing seriousness of the urban
transport impact on the environment and an awareness of the importance of international
collaboration for dealing with it.

The WCTRS is an international forum bringing together researchers and practitioners in
transport, which has extended beyond established disciplines such as engineering and
economics, and modes of transport like railways, roads, shipping and aviation, to include
experts in a variety of fields including logistics, land use, and financing. Concerning the
problems of transport and the environment in cities, it was considered essential to carry out
research by bringing together experts from representative cities around the world. It was
decided that researchers with a deep interest in the environment would be selected from among
the members of WCTRS, and an international research programme under the title of
“Comparative Study on Urban Transport and the Environment (CUTE)” would be undertaken.
It was only the wealth of human resources within the WCTRS, and the long-standing relations
of trust among individual members, that made it possible for the authors to realise this
challenging systematic work “Urban Transport and the Environment”.

The research was started on the initiative of Hideo Nakamura of the ITPS (Institute for
Transport Policy Studies, Tokyo) as a joint research project with the WCTRS. The overall
progress of the research and the details of its structure were ensured by Hideo Nakamura,
Yoshitsugu Hayashi, Anthony D. May and Kazuaki Miyamoto, and the research was conducted
through the cooperation of Werner Rothengatter, Genevieve Giuliano, Daniel Sperling, Alain
Bonnafous, Dominique Mignot and Wolfgang Schade, requiring six major meetings and
innumerable e-mail communications. Some of these members also served as lead authors for
individual chapters.

In addition to the lead authors, chapter sections were contributed by the researchers
listed below. As it was our purpose not only to understand the general mechanisms of the
transport environment problems but also to share experiences of various practices that have
been adopted in different cities of the world, we requested other researchers who had expert
knowledge of practice in these cities to join our project as writers.

The secretariat for this research, provided by the ITPS, bore the responsible for
maintaining steady progress in the research and writing. We gratefully acknowledge the
support of the Japanese Ministry of Land, Infrastructure and Transport and of the Nippon
Foundation. In addition, we especially thank former Vice Minister Jiro Hanyu in person, for his
invaluable advice from the first proposal of the CUTE project up to final publication.
Representing the editors,

Hideo Nakamura, Director, Institute for Transport Policy Studies, Tokyo  
Professor, Musashi Institute of Technology  
Former President, World Conference on Transport Research Society (WCTRS)

Yoshitsugu Hayashi, Professor, Graduate School of Environmental Studies, Nagoya University  
Chair, Special Interest Group on Transport and the Environment, WCTRS

Anthony D. May, Professor and Director, Institute for Transport Studies, University of Leeds  
Chair, Special Interest Group on Transport Policy Instruments, WCTRS
COMPARATIVE STUDY ON
URBAN TRANSPORT AND THE ENVIRONMENT
(CUTE)

2001-2004

Members of CUTE Project
Yoshitsugu HAYASHI (Nagoya University) [Project Chair]
Alain BONNAFOUS (L'université Lumière Lyon)
Genevieve GIULIANO (University of Southern California, Los Angeles)
Shinya HANAOKA (Asian Institute of Technology, Bangkok)
Hirokazu KATO (Nagoya University)
Anthony D. MAY (University of Leeds)
Dominique MIGNOT (L'université Lumière Lyon)
Kazuaki MIYAMOTO (Tohoku University, Sendai)
Hideo NAKAMURA (Institute for Transport Policy Studies, Tokyo)
Werner ROTHENGATTER (University of Karlsruhe)
Wolfgang SCHADE (University of Karlsruhe)
Daniel SPERLING (University of California, Davis)
Masaharu YAGISHITA (Nagoya University)

Secretariat
Mikiharu ARIMURA (Institute for Transport Policy Studies, Tokyo)
Yuichiro KANEKO (Institute for Transport Policy Studies, Tokyo)
Masanobu KII (Institute for Transport Policy Studies, Tokyo)
Akira OKADA (Institute for Transport Policy Studies, Tokyo)
LIST OF AUTHORS

Lead Authors
Hideo NAKAMURA (Chapter 1)
Genevieve GIULIANO (Chapter 2)
Daniel SPERLING (Chapter 3)
Anthony D. MAY (Chapter 4)
Kazuaki MIYAMOTO (Chapter 5)
Werner ROTHENGATTER (Chapter 6)

Authors
Surya Raj ACHARYA (Institute for Transport Policy Studies, Tokyo) [5.19, Box 7]
Mohammed Abdul AZIZ (National University of Singapore) [5.22]
Mikiharu ARIMURA (Institute for Transport Policy Studies, Tokyo) [1, Box 9]
Jean-Michel CUSSET (Laboratoire d’Économie des Transports, Lyon) [5.10, 5.18]
Tien Fang FWA (National University of Singapore) [5.22]
Haluk GERÇEK (Technical University of Istanbul) [5.4, Box 3]
Genevieve GIULIANO (University of Southern California, Los Angeles) [2.1, 2.2.3, 2.3.1–2.3.2, 2.4, 2.6]
Shinya HANAOKA (Asian Institute of Technology, Bangkok) [3.1–3.3, 3.5.1, Box 8]
Yoshitsugu HAYASHI (Nagoya University) (Introduction, 6.1, 6.2, 6.5]
Burkhard E. HORN (International University, Niigata) [2.3.3]
Balazs HORVATTH (TRANSMAN Ltd., Budapest) [5.3]
Ali S. HUZAYYIN (Cairo University) [5.8, Box 19]
Bruce JAMES (City of Nottingham) [5.6]
Hirokazu KATO (Nagoya University) [2.4.1, 4.9, 5.14, 6.2, 6.5, Box 2, Box 21]
Masanobu KII (Institute for Transport Policy Studies, Tokyo) [2.3.3, Box 6]
Yoshikuni KOBAYASHI (Institute for Transport Policy Studies, Tokyo) [1, 2.2.1, 3.4]
Hanh Dam LE (University of Southern California, Los Angeles) [5.9]
Sungwon LEE (Korea Transport Institute, Seoul) [5.21]
Francisco J. MARTINEZ (University of Chile, Santiago) [5.13]
Anthony D. MAY (University of Leeds) [4.1–4.4, 4.6–4.8, Box 12–18]
Dominique MIGNOT (L’université Lumière Lyon) [2.2.2, 2.3.3, 5.5]
Kazuaki MIYAMOTO (Tohoku University, Sendai) [2.4.1, 4.3.3, 5.1]
Janos MONIGL (TRANSMAN Ltd., Budapest) [5.3]
Antonio N. MUSSO (University of Rome “La Sapienza”) [5.7, Box 10]
Fumihiko NAKAMURA (Yokohama National University) [5.11]
Hideo NAKAMURA (Institute for Transport Policy Studies, Tokyo) (Introduction, 1, 3.4]
Jean-Pierre NICOLAS (L’université Lumière Lyon) [5.5]
Akira OKADA (Institute for Transport Policy Studies, Tokyo) [2.3.2, 3.1, 3.2.2, 3.5.1]
Makoto OKAZAKI (Tottori University of Environmental Studies) [3.2.1, 3.3.2, 4.5]
Omar OSMAN (Cairo University) [5.8, Box 19]
Antonio PÁEZ (McMaster University, Hamilton) [5.12, Box 19]
Rodrigo QUIJADA (Ciudad Viva, Santiago) [5.13]
Werner ROTHENGATTER (University of Karlsruhe) [6.3, 6.5.1]
Wolfgang SCHADE (University of Karlsruhe) [3.6, 5.2, Box 1, Box 11, Box 20]
Daniel SPERLING (University of California, Davis) [2.5, 3.2.1, 3.5.2–3.5.4, 4.5, 6.4, Box 5, Box 23]
Yordphol TANABORIBOON (Asian Institute of Technology, Bangkok) [5.16, Box 4]
Michael A.P. TAYLOR (University of South Australia, Adelaide) [5.15]
Varameth VICHIENSAN (Tohoku University, Sendai) [4.3.3]
Karl N. VERGEL (University of the Philippines, Manila) [5.20, Box 22]
Masaharu YAGISHITA (Nagoya University) [3.2, 3.3]
Zhongzhen YANG (Dalian University of Technology) [5.17]
Rocco ZITO (University of South Australia, Adelaide) [5.15]
# List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Chapter structure of this book</td>
<td>5</td>
</tr>
<tr>
<td>1.2</td>
<td>Means of transport covered in the Comparative study on Urban Transport and the Environment (CUTE)</td>
<td>6</td>
</tr>
<tr>
<td>1.3</td>
<td>Environmental problems covered in CUTE</td>
<td>7</td>
</tr>
<tr>
<td>1.4</td>
<td>Objectives and alternative strategies for transport and land use policy</td>
<td>8</td>
</tr>
<tr>
<td>1.1.1</td>
<td>Change in number of trips and shares by different transport modes</td>
<td>13</td>
</tr>
<tr>
<td>1.1.2</td>
<td>Change in vehicle ownership in developed countries from 1926 to 1960</td>
<td>16</td>
</tr>
<tr>
<td>1.2.1</td>
<td>Average air pollution of high income and middle / low income countries (1995)</td>
<td>26</td>
</tr>
<tr>
<td>1.3.1</td>
<td>Proportional volumes of CO\textsubscript{2} emitted by various countries of the world</td>
<td>31</td>
</tr>
<tr>
<td>2.2.1</td>
<td>Personal vehicles and per capita GDP, 1998</td>
<td>41</td>
</tr>
<tr>
<td>2.2.2</td>
<td>Rate of motorization vs income level, 54 countries, 1990–1996</td>
<td>42</td>
</tr>
<tr>
<td>2.2.3</td>
<td>Vehicle ownership, U.S. by year and 1998 selected world regions</td>
<td>43</td>
</tr>
<tr>
<td>2.2.4</td>
<td>Projections of motorisation, 1980–2020</td>
<td>44</td>
</tr>
<tr>
<td>2.2.5</td>
<td>Automobiles per 1000 persons, 1991-2000</td>
<td>46</td>
</tr>
<tr>
<td>2.2.6</td>
<td>Trucks per 1000 persons, 1991-2000</td>
<td>46</td>
</tr>
<tr>
<td>2.2.7</td>
<td>Stock of trucks (thousand), base 100, 1995-2001</td>
<td>49</td>
</tr>
<tr>
<td>2.2.8</td>
<td>Trends in public transport bus fleet, 1970 - 2000</td>
<td>50</td>
</tr>
<tr>
<td>2.3.1</td>
<td>Trends in annual VKT, selected U.S. metro areas. 1960–1990</td>
<td>57</td>
</tr>
<tr>
<td>2.3.2</td>
<td>Trends in annual VKT, selected European metro areas, 1960–1990</td>
<td>57</td>
</tr>
<tr>
<td>2.3.3</td>
<td>Trends in annual VKT, selected Asian metro areas, 1960–1990</td>
<td>57</td>
</tr>
<tr>
<td>2.3.4</td>
<td>Average mode shares</td>
<td>61</td>
</tr>
<tr>
<td>2.3.5</td>
<td>Mode shares, North America metro areas</td>
<td>62</td>
</tr>
<tr>
<td>2.3.6</td>
<td>Mode shares, metro areas in Germany, France, UK</td>
<td>63</td>
</tr>
<tr>
<td>2.3.7</td>
<td>Mode shares, other EU metro areas</td>
<td>63</td>
</tr>
<tr>
<td>2.3.8</td>
<td>Mode shares, Asian metro areas</td>
<td>64</td>
</tr>
<tr>
<td>2.3.9</td>
<td>Average mode shares of countries by income group</td>
<td>64</td>
</tr>
<tr>
<td>2.3.10</td>
<td>Mode shares, selected developing countries</td>
<td>68</td>
</tr>
<tr>
<td>2.3.11</td>
<td>Growth in freight tonnage by mode, U.S., 1960–1998, ton-mile billions</td>
<td>70</td>
</tr>
<tr>
<td>2.3.12</td>
<td>Growth in freight tonnage by mode, EU 15 countries, 1970–2000, ton-kilometre billions</td>
<td>71</td>
</tr>
<tr>
<td>2.3.13</td>
<td>Trends in population, employment and measures of transport, Los Angeles region, 1981–1997</td>
<td>72</td>
</tr>
<tr>
<td>2.3.14</td>
<td>Transport distance per ton in Tokyo</td>
<td>74</td>
</tr>
<tr>
<td>2.3.15</td>
<td>Number of truck companies in Japan</td>
<td>74</td>
</tr>
<tr>
<td>2.3.16</td>
<td>Increase and decrease of commodities transport volume, 1995–2000, in Japan</td>
<td>75</td>
</tr>
<tr>
<td>2.3.17</td>
<td>Changes in capacity ton-kms and transport ton-kms of the freight vehicle</td>
<td>75</td>
</tr>
</tbody>
</table>
2.4.1 Average annual private sector job growth
2.4.2 City and suburban population growth, selected European cities
2.4.3 Change in resident population, Sendai metro area, Japan, 1992–2002
2.4.4 Expansion of densely inhabited district area in Iida city, Japan, 1970–1990
2.4.5 Expansions of Bangkok during past decades
2.5.1 Illustrating the relationship between mode choice and income
3.1.1 Inventory of atmospheric gas in the U.S. (Year of 2000)
3.1.2 Energy intensity and population density in cities
3.1.3 Energy use per passenger of each mode in representative cities
3.2.1 Impacts of air-fuel ratio on engine performance and characteristics of exhaust gas
3.2.2 Share of freight vehicles by registered year 2002
3.2.3 Passenger vehicle emission regulation in Asian countries
3.3.1 Emission – velocity (speed) curve of carbon monoxide
3.3.2 Trends in emission inventory of major air pollutants in U.S.
3.3.3 Emission inventory of major air pollutants in Europe
3.3.4 Transition in emission of major air pollutants in Europe (1990=100)
3.3.5 Emission inventory of automobile sector sources in Japan (2000)
3.3.6 State of car transport during winter (Sapporo)
3.3.7 Reduction in the amount of falling dust generated during winter in Sapporo and the corresponding reduction in spike tyre usage (1988–1995)
3.3.8 Conceptual figure of mutual relationship among air pollutants and spatial distribution in urban areas
3.3.9 Distance attenuation of NO, NO₂ from edge of the road
3.3.10 Distribution of air pollution monitoring stations in the U.S. (SLAMS and NAMS)
3.3.11 Trends in average pollution concentrations in Japan of NO, NO₂ and PM10
3.4.1 Urban population density, and concentrations of SPM, SO₂, and NO₂
3.4.2 Annual emissions of transport related pollutants
3.4.3 An electric scooters’ recharging station
3.5.1 Changes in CO₂ emission levels in the major developed countries
3.6.1 Children’s prize winning pictures to illustrate noise
3.6.2 Survey on experienced transport noise pollution in West Germany
3.6.3 Distribution of outdoor noise levels from roads during the day affecting the Swiss
3.6.5 European noise emission standards for road transport vehicles
4.3.1 Land use transport interaction
4.4.1 Causal loop diagram: the impacts of changes in road capacity
4.4.2 Causal loop diagram: the impacts of changes in road and rail capacity
4.7.1 Percentage of European cities having full, joint and no responsibility for different policy instruments

4.7.2 Percentage of European cities having differing levels of dependence on other authorities

4.7.3 Percentage of European cities for whom finance is a major or minor constraint on different policy instruments

4.7.4 Percentage of cities for whom political barriers are a major or minor constraint on different policy instruments

4.8.1 The optimisation process

4.9.1 Causal loop diagram (1): reduce car use

4.9.2 Causal loop diagram (2): improve alternative modes

4.9.3 Causal loop diagram (3): improve road network

4.9.4 Causal loop diagram (4): improve vehicles and fuels

4.9.5 Example of application of causal loop diagram in Nagoya (1998)

4.9.6 Example of application of causal loop diagram in Jakarta (1998)

5.1.1 Distribution of case study cities

5.2.1 Comparison of the development of population in West and East Berlin

5.2.2 Potsdamer Platz in 1961 and in 2003 after it became the new city center of Berlin

5.2.3 Modal-split in the two parts of Berlin before reunification in 1989

5.2.4 Modal-split of motorized passenger trips for total Berlin after reunification

5.2.5 Car ownership in West and East Berlin compared with Hamburg and West Germany

5.2.6 Development of migration flows between Berlin and its Hinterland

5.2.7 Age structure of migration balance between Berlin and its Hinterland

5.2.8 Average concentrations in Berlin 1990 – 2000

5.2.9 NO\textsubscript{x} concentrations at three locations in Berlin

5.2.10 CO\textsubscript{2} emissions in Berlin

5.3.1 Development of car fleet and public transport (1990=100)

5.3.2 Air pollution in Budapest (1980-2000) - yearly average emission

5.4.1 Major roads in Istanbul

5.4.2 The Bosphorus railway tunnel crossing project

5.5.1 Population densities within Greater Lyon

5.5.2 Distances covered by mode according to the place of residence

5.5.3 Average annual concentrations of different pollutants in the Lyon agglomeration

5.5.4 Emission rates in m\textsuperscript{2} per zone, linked to Lyons inhabitant mobility

5.5.5 The Greater Lyons public transport system 2003-2006

5.6.1 Integrated transport framework

5.9.1 SCAG region and population density in 2000 census
5.9.2 Distribution of population and employment by county
5.9.3 Commuting patterns in metropolitan Los Angeles
5.9.4 Highway use and performance
5.9.5 Commuter rail, urban rail and rapid bus system in the SCAG region
5.9.6 Improved air quality in the SCAG region
5.9.7 Evolution of California auto controls: pollutants emitted by a new vehicle
5.9.8 Emissions trends from on-road motor vehicles in SCAB
5.9.9 Technology-driven mobile source emissions control
5.9.10 Particulate mater (PM10)
5.10.1 Transmilenio
5.11.1 The development axis in Curitiba
5.11.2 Speedy bus and specially designed tube-bus stop
5.12.1 Modal share by mode
5.13.1 Number of motorized trips and mode splits in week-day for 1991 and 2001
5.13.2 Total emissions per year
5.13.3 Responsibility for emissions, year 2000
5.13.4 Responsibility for transport emissions, by vehicle type, year 2000
5.13.5 Contingences declared, 1990-2001
5.13.6 PM10 concentration (µg/m³) during the July/3-6/2000 episode and effectiveness of the “emergency traffic network” (RVE)
5.13.7 Opinions about the trend of air quality
5.14.1 Nagoya –area and public transport network–
5.14.2 100m width street in central Nagoya
5.14.3 Relationship between population density and passenger car ownership in principal Japanese cities in 1995
5.14.4 Changes in the number of passengers carried by various modes of transport in Nagoya metropolitan area
5.14.5 Changes in the vehicle-km and ton travelled by freight vehicles in Aichi Prefecture
5.14.6 Changes in concentration of various air pollutants in the city of Nagoya (Annual average of all monitoring stations)
5.14.7 Bus system introduced in Nagoya
5.14.8 Average fuel economy for new passenger cars in Japan
5.14.9 Route-no.23, where air pollution is very serious
5.16.1 Trends of new vehicles registered in Bangkok as compared with the base year 1997
5.17.1 Car ownership in the main city by year
5.17.2 Surveyed pollutants at 5 monitoring stations in the Dalian city
5.18.1 Hanoi public transport in the modal split 1975-2002
5.18.2 Road traffic in Hanoi
5.19.1 Map of Kathmandu valley 379
5.19.2 Vehicle population trend in Kathmandu valley 381
5.20.1 Jeepneys used for public transport in metro Manila 384
5.20.2 Vehicle registration by fuel type in metro Manila, 1980-2001 385
5.20.3 Smoke-belching bus being subjected to roadside inspection 387
5.22.1 Percentage composition of vehicles in Singapore in 1999 395
6.3.1 Diesel vehicles (cars and LDVs) as a percentage of all newly licensed vehicles up to 5 tons in Western Europe 419
6.3.2 Forecast for the concentration of soot and particulate matter along an arterial road in Berlin 421
6.4.1 Greenhouse gas emissions due to transport: results from scenario analyses (ratio of forecasted emissions in 2020 to actual emissions in 2000) 435
6.5.1 ODA in the transport sector in Japan 440
6.5.2 An implementation of CDM to a railway construction project 442
6.5.3 FEST system coordinating GEF and CDM 445

**LIST OF TABLES**

1.2.1 Variation in vehicle ownership in different groups of countries, classed by income 25
1.2.2 Estimates for transport-related energy consumption 25
1.3.1 Conferences of parties to the framework convention on climate change 30
1.3.2 Evolution in volume of world CO₂ emissions 32
1.3.3 CO₂ emission and energy production (1995) 33
1.3.4 Energy consumption by sectors (1985 and 1995) 33
1.3.5 Forecasts of energy consumption and CO₂ emissions 34
2.2.1 Trends in world motor vehicle fleet 40
2.2.2 Vehicle ownership by UN world region, 1998 41
2.2.3 Vehicle ownership, rate of increase, income elasticity, by World Bank income category, 1988-1998 42
2.2.4 Country level vehicle ownership forecast, by World Bank income category 44
2.2.5 Median age of passenger car fleet (years), by country, year 47
2.2.6 New passenger car average engine cubic capacity (cm³) by country by year, selected European countries 47
2.2.7 Trends in U.S. goods movement vehicle fleet, registered vehicles (millions) 49
2.2.8 Trends in U.S. public transport vehicle fleet 49
2.2.9 Trends in European public transport vehicle fleet 50
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2.10</td>
<td>Explanatory factors for differences in car use, selected countries</td>
<td>54</td>
</tr>
<tr>
<td>2.2.11</td>
<td>Surface transport infrastructure per capita</td>
<td>54</td>
</tr>
<tr>
<td>2.3.1</td>
<td>Mode shares trends, all person trips, selected urban areas</td>
<td>58</td>
</tr>
<tr>
<td>2.3.2</td>
<td>Car ownership, U.S. and Great Britain, 1995, share of persons</td>
<td>59</td>
</tr>
<tr>
<td>2.3.3</td>
<td>Average daily person trips, travel distance, travel time, U.S. and Great Britain</td>
<td>59</td>
</tr>
<tr>
<td>2.3.4</td>
<td>Mode shares, U.S. and Great Britain</td>
<td>60</td>
</tr>
<tr>
<td>2.3.5</td>
<td>Paratransit services in developing countries</td>
<td>66</td>
</tr>
<tr>
<td>2.3.6</td>
<td>Freight transport in a German metropolitan area</td>
<td>72</td>
</tr>
<tr>
<td>2.3.7</td>
<td>Dominant environmental measures in logistics sector</td>
<td>76</td>
</tr>
<tr>
<td>2.4.1</td>
<td>Population growth for U.S. metro areas with 1 million or more population, central and suburban counties</td>
<td>79</td>
</tr>
<tr>
<td>2.4.2</td>
<td>City and suburban population shares, France, 1975-1999</td>
<td>81</td>
</tr>
<tr>
<td>2.4.3</td>
<td>City and suburban employment shares, France, 1975-1999</td>
<td>81</td>
</tr>
<tr>
<td>2.4.4</td>
<td>Employment change by type and local authority district, 1984-91-96, in Full-Tire Equivalent, percent</td>
<td>82</td>
</tr>
<tr>
<td>2.4.5</td>
<td>Commute flows in U.S. metropolitan areas, 1980 and 1990</td>
<td>88</td>
</tr>
<tr>
<td>2.4.6</td>
<td>Journey to work mode choice, 1995, by job location, U.S.</td>
<td>88</td>
</tr>
<tr>
<td>2.4.7</td>
<td>Journey to work mode choice, 1995, by job location, Greater London</td>
<td>88</td>
</tr>
<tr>
<td>3.2.1</td>
<td>Passenger vehicle emission control in Europe</td>
<td>110</td>
</tr>
<tr>
<td>3.2.2</td>
<td>Passenger vehicle emission control in the U.S.</td>
<td>111</td>
</tr>
<tr>
<td>3.2.3</td>
<td>Passenger vehicle emission control in Japan</td>
<td>111</td>
</tr>
<tr>
<td>3.3.1</td>
<td>Classification of air pollutants by EEA</td>
<td>114</td>
</tr>
<tr>
<td>3.3.2</td>
<td>List of mobile source air toxics (MSATs)</td>
<td>116</td>
</tr>
<tr>
<td>3.3.3</td>
<td>Environmental standards of WHO, Japan, U.S. and Europe</td>
<td>118</td>
</tr>
<tr>
<td>3.3.4</td>
<td>Emission levels of pollutants of vehicle types</td>
<td>120</td>
</tr>
<tr>
<td>3.3.5</td>
<td>Rate of major air pollutants in Europe from 1990 to 1999</td>
<td>124</td>
</tr>
<tr>
<td>3.3.6</td>
<td>NOx emission levels in Japanese metropolitan areas</td>
<td>124</td>
</tr>
<tr>
<td>3.3.7</td>
<td>Monitoring methods of major air pollutants in Japan</td>
<td>130</td>
</tr>
<tr>
<td>3.3.8</td>
<td>Status of air pollution monitoring stations in European countries</td>
<td>133</td>
</tr>
<tr>
<td>3.3.9</td>
<td>Number of monitoring stations for each air pollutant in Japan (as of 2000)</td>
<td>134</td>
</tr>
<tr>
<td>3.4.1</td>
<td>Pollutant emission levels per unit area (ton/ha) and their correlation</td>
<td>139</td>
</tr>
<tr>
<td>3.4.2</td>
<td>Density, modal share, and atmospheric pollution from private vehicles</td>
<td>140</td>
</tr>
<tr>
<td>3.4.3</td>
<td>Correlation coefficient between the level of pollutant emissions and index</td>
<td>144</td>
</tr>
<tr>
<td>3.5.1</td>
<td>CO2 emission level in major developed countries (2000)</td>
<td>148</td>
</tr>
<tr>
<td>3.5.2</td>
<td>CO2 emissions and vehicles per capita for selected countries (1998)</td>
<td>153</td>
</tr>
<tr>
<td>3.5.3</td>
<td>Greenhouse gas emissions from vehicles and transport modes in developing countries</td>
<td>153</td>
</tr>
<tr>
<td>3.5.4</td>
<td>Policy and investment choices to reduce vehicle use and greenhouse gas emissions</td>
<td>157</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>3.6.1</td>
<td>Exposure to transport noise in Germany as share of affected population</td>
<td>169</td>
</tr>
<tr>
<td>3.6.2</td>
<td>Comparison of percentages of people reporting annoyance because of</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>transport noise in surveys</td>
<td></td>
</tr>
<tr>
<td>3.6.3</td>
<td>Estimates of shares of Italian population affected by different noise levels</td>
<td>171</td>
</tr>
<tr>
<td></td>
<td>in 1997</td>
<td></td>
</tr>
<tr>
<td>3.6.4</td>
<td>Measurement of noise levels at 1000 dwellings in the UK in 1990</td>
<td>171</td>
</tr>
<tr>
<td>3.6.5</td>
<td>Number of U.S. citizens exposed to transport noise from different modes</td>
<td>172</td>
</tr>
<tr>
<td>3.6.6</td>
<td>Examples of noise levels in developing countries from the WHO report</td>
<td>172</td>
</tr>
<tr>
<td></td>
<td>(1999)</td>
<td></td>
</tr>
<tr>
<td>3.6.7</td>
<td>Noise immission standards of the German 16th BimSchV</td>
<td>174</td>
</tr>
<tr>
<td>3.6.8</td>
<td>Zoning system for noise protection in Switzerland</td>
<td>176</td>
</tr>
<tr>
<td>3.6.9</td>
<td>Environmental standards for road transport noise in Switzerland</td>
<td>176</td>
</tr>
<tr>
<td></td>
<td>according to LSV87</td>
<td></td>
</tr>
<tr>
<td>3.6.10</td>
<td>Dutch noise immission standards according to Noise Abatement Act 1979</td>
<td>177</td>
</tr>
<tr>
<td>3.6.11</td>
<td>Japanese noise immission standards according to Environment Agency</td>
<td>179</td>
</tr>
<tr>
<td></td>
<td>notification No 64</td>
<td></td>
</tr>
<tr>
<td>3.6.12</td>
<td>Noise immission standards for different countries for residential zones</td>
<td>181</td>
</tr>
<tr>
<td></td>
<td>and road transport</td>
<td></td>
</tr>
<tr>
<td>4.2.1</td>
<td>Contribution of strategies to objectives</td>
<td>200</td>
</tr>
<tr>
<td>4.3.1</td>
<td>Classification of policy instruments and their contribution to transport and</td>
<td>203</td>
</tr>
<tr>
<td></td>
<td>environmental strategies</td>
<td></td>
</tr>
<tr>
<td>4.5.1</td>
<td>Emission reduction technologies for petrol engines</td>
<td>224</td>
</tr>
<tr>
<td>4.5.2</td>
<td>Emission reduction technologies for diesel engines</td>
<td>224</td>
</tr>
<tr>
<td>4.5.3</td>
<td>Technologies for vehicles using alternative energies</td>
<td>225</td>
</tr>
<tr>
<td>4.5.4</td>
<td>Recent fuel cell powered vehicles</td>
<td>229</td>
</tr>
<tr>
<td>4.5.5</td>
<td>Performance comparison of vehicle technology</td>
<td>232</td>
</tr>
<tr>
<td>4.6.1</td>
<td>Contributions of different types of instrument to strategies</td>
<td>234</td>
</tr>
<tr>
<td>4.6.2</td>
<td>Contribution of policy instruments to objectives in city centres</td>
<td>235</td>
</tr>
<tr>
<td>4.6.3</td>
<td>Contribution of policy instruments to objectives in inner suburbs</td>
<td>235</td>
</tr>
<tr>
<td>4.6.4</td>
<td>Contribution of policy instruments to objectives in outer suburbs</td>
<td>236</td>
</tr>
<tr>
<td>4.6.5</td>
<td>Contribution of policy instruments to objectives in smaller urban areas</td>
<td>236</td>
</tr>
<tr>
<td>4.8.1</td>
<td>An integration matrix, illustrating the ways in which policy instruments</td>
<td>242</td>
</tr>
<tr>
<td></td>
<td>may contribute to the performance of others</td>
<td></td>
</tr>
<tr>
<td>5.2.1</td>
<td>Distribution of daily traffic volume on the main road network of Berlin</td>
<td>260</td>
</tr>
<tr>
<td>5.2.2</td>
<td>Key data of public transport in Berlin for 1999</td>
<td>262</td>
</tr>
<tr>
<td>5.4.1</td>
<td>Population and motorisation in Istanbul (1980-2000)</td>
<td>283</td>
</tr>
<tr>
<td>5.4.2</td>
<td>Modal split of daily motorised trips</td>
<td>283</td>
</tr>
<tr>
<td>5.4.3</td>
<td>Emissions caused by road traffic in Istanbul</td>
<td>284</td>
</tr>
<tr>
<td>5.5.1</td>
<td>Distribution of population and employment in the Lyon urban area in</td>
<td>287</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td></td>
</tr>
</tbody>
</table>
5.5.2 Modal distribution for commuting, by urban area and by origin – destination
5.5.3 Perception of pollution and living conditions for the French
5.6.1 Travel mode shares for Nottingham
5.6.2 Air pollution exceedences in Nottingham
5.7.1 Rome’s public transport statistics (year 2000)
5.7.2 Rome municipality area private vehicles fleet size (year 2000)
5.7.3 Rome municipality area vehicles, according to the fuel used (2001)
5.7.4 Emissions in the Rome municipality area
5.7.5 Motorized two wheels fleet size (year 2000)
5.7.6 Overall emissions generated by all the motorised modes in the “Tridente” area from 8.00 to 9.00 am, during a working day (year 2001)
5.7.7 Average specific CO₂ emissions of the Italian car fleet size
5.8.1 Air pollution indicators at 15 survey locations, autumn 2001
5.9.1 Primary travel mode for work trips in the SCAG region
5.13.1 Key government measures to reduce air pollution
5.13.2 Measures included in “contingences scheme” as of September 28th, 2002
5.14.1 Transport policies for a better environment in Nagoya
5.15.1 Modal splits for passenger trips in Adelaide
5.15.2 Representative air pollutant concentrations in an inner suburb of Adelaide
5.16.1 Ambient air quality in general area and at the roadside in Bangkok
5.16.2 Annual emissions of Air contaminants in Bangkok, 1997
5.17.1 Surveyed modal split in the main city
5.17.2 Comparison of equivalent noise level along roads in 1995 and 2000
5.18.1 Bicycle and motorbike ownership trends
5.19.1 Concentration range of major pollutants at different test sites in Kathmandu
5.19.2 Monthly average concentration of PM10 at the permanent monitoring stations
5.20.1 Registration by vehicle type in metro Manila, 2001
5.20.2 Transport demand by mode in metro Manila, 1996
5.20.3 Greenhouse gas emissions (1994)
5.21.1 Air pollutants emission trend by automobiles
5.21.2 Energy consumption trend by sector in Korea
5.21.3 CO₂ emission trend by sector in Korea
5.22.1 Demographic trends, population prediction, households, elderly and employment
5.22.2 Trends in car ownership and travel
5.22.3 Comparison of the atmospheric mean concentration of BC, CO and NO at different sites in Singapore
5.22.4 Average traffic noise levels at 4 locations among three different classes of roads in Singapore

6.1.1 Major political occurrences concerning transport environment policies

6.2.1 Facts and first results of the London area pricing

6.3.1 Share of particle emissions due to exhaust and non-exhaust processes

6.3.2 Differentiation in use-of-infrastructure charges on heavy goods vehicles on German motorways in cents per vehicle km

LIST OF BOXES

1 Success and failures of the “Karlsruher modell” for public transport 64
2 Environmental measures for the logistics sector – lessons in Japan 75
3 Migration to the city, illegal housing and transport system 82
4 Old Venice of the east is now one of the most traffic congested cities 84
5 The two-wheeler mystery 93
6 Age of freight vehicles and emission control regulations in Japan 112
7 Air pollution in Kathmandu valley takes its toll on tourism industry 116
8 Emission factors for petrol engine and diesel engine vehicles in Tokyo 120
9 Atmospheric pollution caused by the use of spike tyres in Japan 125
10 Electric scooters in Rome 143
11 Noise protection policy in Germany 185
12 Potential objectives of urban transport policy 196
13 Key elements of an urban transport strategy 198
14 The structured approach in KonSULT 208
15 Infrastructure policy instruments in KonSULT 209
16 Regulatory policy instruments in KonSULT 213
17 Information provision and enlightenment instruments in KonSULT 218
18 Pricing instruments in KonSULT 221
19 Use of alternative fuels in Greater Cairo and Mexico City 232
20 Ten years of citizens fight against unacceptable noise and air pollution at the Brückenstrasse 240
21 The air pollution lawsuits in the southern part of Nagoya 357
22 Non-governmental activities for clean air in Manila 433
23 Four case studies 435
FRONTPAGE PHOTOGRAPHS

Intro  Traffic congestion in Bangkok by Shinya Hanaoka.
Intro  Traffic congestion in Chicago by Express Highway Research Foundation of Japan.
Chap1  Congested highway in Tokyo by Metropolitan expressway public corporation.
Chap1  Buses at Portland by Yuichiro Kaneko.
Chap2  Subway in Nagoya by Hirokazu Kato.
Chap2  Buses at Curitiba by Fumihiko Nakamura.
Chap3  Smoking-belching bus in Manila by the Partnership for Clean Air.
Chap3  High occupancy vehicle lane in Los Angeles by Express Highway Research Foundation of Japan.
Chap4  Bicycle lane in Gauteng by the Institute of Behavioral Sciences.
Chap4  Electric road pricing gantry in Singapore by Tomonori Nagase.
Chap5  Light Rail Transit in Lyon by Shinya Hanaoka.
Chap5  General road in Hanoi by Atsushi Fukuda.
Chap6  Road sign in London by ALMEC Corporation.
Chap6  Transit mall in Karlsruhe by Naohiko Hibino.
INTRODUCTION

AUTHORS

Yoshitsugu Hayashi
Hideo Nakamura
INTRODUCTION

1.1 The Present State of Transport-related Environmental Problems

In developed countries, there are notable examples of countermeasures to lighten the burden that traffic imposes on the environment. In Freiburg, Germany, a rail link allows direct access from the city centre tram mall to the residential suburbs on the one hand and the main line rail station on the other, which has led to a significant shift to public transport. In Japan the “green” car tax system has encouraged purchase of vehicles with low rates of emission and fuel consumption. In the UK, the concept of Integrated Transport has established itself as a mainstay of transport policy. In the Netherlands, too, the national transport policy is remarkable in that it is concerned with location regulations which take into consideration the available transport systems in the area and actually seeks for slower transport modes in towns.

In developing and newly industrialised countries, also, there are numerous creditable examples to be found. For example, the raising of the taxation rate on leaded petrol in Thailand led successfully in just a few years to a national changeover to unleaded fuel. Or there is the case of Cairo, in Egypt, where the attractive, recently introduced underground system, together with the well utilised traditional suburban tramways, has allowed rail to maintain a 20% share of public transport for the past twenty years, a figure that would be notably high in a developed country, let alone a developing one.

However, it can hardly be said that good practices like these are being readily transferred from one country to another. There may well be these individual success stories, both in the developed and developing worlds, yet in the end there is no denying the overall picture which is that attempts to use transfer of policies as a means for dealing with transport-related environmental problems are generally feeble, and individual policy initiatives are not systematically organised.

One of the barriers is that the relationships between transport and the environment are extremely complicated. To give one example, the advances in engine technology development achieved by automobile manufacturers in developed countries since the latter half of the 1990s have been truly remarkable from an environmental point of view. In Japan, as a result of the introduction of a “green” car tax preference, there has been a very rapid shift among consumers to cars with lower fuel consumption, and this in turn spurs competition in technology development among the manufacturers, leading to a positive chain reaction. This example shows how it is possible to control the load imposed on the environment by traffic once the mechanisms linking the multiple parties have been properly grasped and effective policies have been discerned. However, in developing countries, there is a widespread demand among consumers for poor quality second-hand cars and engines at extremely low prices. It is extremely difficult to control this unless there are policy measures that encompass the complex mechanisms operating between demand and supply. Unless the chain mechanisms linking the
multiple parties can be grasped in this way, and effective policies discerned, it will be extremely difficult to control the load imposed by traffic on the environment.

Research to date, however, has concentrated on advances in discrete areas of analysis such as car ownership, travel behaviour models, traffic management, energy consumption, life cycle assessment, pollution diffusion, environment tax schemes, urban planning regulation and the like. Comprehensive analyses of environmental influences taking transport as their focus have rarely been attempted. Moreover, transport-related environmental problems clearly differ regionally between Europe, America, Japan, the newly industrialised and the developing nations, in terms of problems, public awareness and the assignment of priorities. Analyses and surveys being conducted are almost invariably concerned with particular regions or countries, and are therefore of little help for a wider understanding of transport environment issues or for projects of international collaboration. One of the important recent exceptions has been the EST (Environmentally Sustainable Transport) project proposed by the OECD to bring to light examples of “best practice” in the area of sustainable transport systems. Now we are at the stage of being able to prepare concrete methods to transfer these models of success to other countries and cities.

The deterioration in the global environment has led to the creation of an international framework of measures, including the establishment of Global Environmental Facilities (GEF) by the World Bank, the proposal and approval of the Kyoto Protocol, and concrete plans for implementing the Kyoto mechanisms in such applications as Clean Development Mechanisms (CDMs). Various projects, including for example afforestation and the re-equipment of electricity generating facilities, have been suggested, and concrete means of implementation are under consideration. But in the transport sector, the sad reality is that virtually no ideas have been put forward.

1.2 The Approaches Required and the Contents of this Book

As will already be apparent from the above remarks, solutions to traffic-related environmental problems depend on the following requirements:

a) understanding these problems within a more comprehensive and general framework
b) the establishment and provision of policy instruments and of a knowledge-base regarding their effects
c) support for policy choices aimed at the improvement of local environments
d) actual case studies of policy applications in representative cities together with “pathology histories” illustrating negative effects
e) institutions and policies that facilitate international collaboration for environmental improvements on a world scale.
Local environmental problems and the effects of the remedial measures exhibit peculiarities specific to the country and region affected as well as to the time of occurrence. It is therefore valuable to know the experiences of other cities and to understand the underpinning explanatory mechanisms. At the same time, in solving environmental problems on the world scale, it is imperative to be able to devise and enact countermeasures jointly, on the basis of a shared international understanding.

Figure 1.1 Chapter structure of this book

For these reasons, this book will not confine itself to the introduction of individual policy examples. Rather, it will follow the structure set out in Figure I.1 below. First, chapter 1, dealing with the environmental problems stemming from urban transport, will trace the path of development that has led from the earliest powered transport to the present day, providing an overall outline of the subject, working from the developed to the developing countries, and from local pollution occurrences to global environmental issues. Following on from this, in chapter 2, we shall be analysing the means and mechanisms by which transport comes to act upon its environment, in particular from the point of view of the various factors that have an effect on transport demand and traffic flow. Chapter 3 then addresses the mechanisms that lead to the generation of exhaust gas emissions, a root cause of traffic pollution, and assesses the impact which they have on the local and global environments. A classification of policy approaches is next undertaken in chapter 4, from the various angles of technology, regulation, information and awareness, and economic measures, applied to such strategy areas as transport demand, traffic flow and sources of emissions. There is also some discussion in this chapter of knowledge bases from which appropriate instruments can be selected. Actual examples of these policies being put into practice and of the benefits accruing from them are presented in chapter 5, for cities such as Nagoya, Los Angeles and Berlin in the developed countries, and
Bangkok, Cairo and Santiago in the developing ones. Finally, chapter 6 offers some future visions and present position statements concerning the prospects for sustainable urban transport.

I.3 The Treatment of “Urban Transport and the Environment” in this Book

As the terms “urban transport” and “environment” are both open to an extremely wide interpretation, it is impossible for this book to describe all of the problems involved in these two areas. For example, air and sea transport also result in toxic gas emissions into the atmosphere, while in certain areas the vibrations caused by rail traffic are a serious environmental hazard. Another concern is that while global environment problems may have grave future effects for the population of the whole planet, actual interest in such matters is very scant in developing countries. However, we as authors neither have the expertise to deal with the entire range of these problems, nor the necessary page space at our disposal were we tempted to try.

We therefore propose to restrict the coverage of this book to the following matters.

Means of transport
The subject treated will be the transport of passengers and goods in cities. The private modes studied will include walking, cycling and individually owned automobiles; the public modes will take in all kinds of motorised transport from railways and trams through automated guideway transit and buses to paratransit. (Figure 1.2).
Environmental problems
Here we shall deal with problems of atmospheric pollution from urban road traffic attributable to causes such as emissions of carbon monoxide (CO), nitrogen oxides (NOx) and particulate matter (PM), and noise pollution due to both rail and road transport, and also with wider-scale local environmental problems such as acid rain, due mainly to exhaust gas emissions from road traffic, and finally the global environment problem arising from the so-called "greenhouse gases" (Figure 1.3).

![Diagram](Image)

Figure 1.3 Environmental problems covered in CUTE

Time span
The time span covered extends from the present to the relatively near future (about 15 or 20 years ahead). Regarding both transport and environmental problems, it is often the case that things that previously went wrong in the developed countries are now occurring again in the developing ones. In some cases it is the results of what happened earlier in the developed world that have led to the present serious situations in the developing world; situations which in turn are now set to aggravate future problems in the same areas. For example, it is not uncommon to find the environmentally harmful automobiles once driven in the developed countries being put to a second use in the developing ones now. Accordingly, our account will have to pay attention to these regional lags in the stages of development, and to the differences in the environmental problems found from one region to another.

Policy objectives
The primary policy objectives as far as this book is concerned are the amelioration of local atmospheric and noise pollution, and the prevention of global warming. At the same time,
however, we need to appreciate the fact that transport exists, and is used, in order to serve other objectives. These objectives may vary somewhat depending on the country or city in question, but most typically they are efficiency, fairness, liveability, equity, safety and economic growth, all of which are valued not only for the present generation but also for future ones. In certain cases, purposes like these may conflict with the kind of environmental improvement objectives we are concerned with in this book, or may be an obstacle to the implementation of an effective environmental strategy. To take one example, a restriction in the use of cars, while desirable from the environmental point of view, might bring an inconvenience in day-to-day living and a loss in production efficiency from the point of view of the people whose mobility is hampered by it. It could also possibly have a detrimental effect on the whole urban economy. On the other hand, it is also possible that the pursuit of these objectives might serve as a reinforcing motive for the policies we are envisaging. For example, effective pricing for the use of a road can result in a double benefits of improved efficiency, convenience and safety on the one hand and environmental improvement on the other. Similarly, an improvement in fuel efficiency leads to a more effective use of resources.

Strategies for the attainment of policy objectives
To meet these objectives, a strategy is needed for the choice of an appropriate direction in policy, taking into consideration geographical features, climate and the socio-economic conditions of the region, as shown in Figure I.4. The principal strategies are likely to be reducing the needs to travel; reducing car use; providing improved alternative to the car,
improving the operation of the road network; and improving vehicles and fuels. The promotion of these alternative strategies requires individual measures of the kinds exemplified in the figure.

*Policy instruments*

The measures for promoting the above mentioned strategies depend for their implementation on a range of technology, regulation, information and public awareness, and economic instruments. In this book, accordingly, the various policy measures will be classified on the two axes of “strategy,” indicating the direction of the intended effect, and “type of instrument.” It is on the matrix thus generated that all the individual policies will be categorised. By way of example, Table 4.3.1 in chapter 4 presents a diverse selection of policy examples fitted in place on this matrix.